Operating and Maintenance Instructions for Brushless Three-phase Generators of the Two-bearing Design, with the Exciter Equipment Attached

MANUAL
GENERADOR
Y
EXCITATRIZ

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1. General

The brushless design three-phase generators satisfies all requirements to be placed on this type of generator as regards technical parameters, reliability in operation, maintenance-free service and workmanship. Electronic voltage regulation provides for high voltage accuracy and excellent dynamic performance. Because of the adaptability of the connection dimensions in particular the manufacturer of Diesel generating sets is offered simplified possibilities of responding quickly to specific situations if need arises.

As to their design and construction the generators meet the requirements of GDR standard TGL 20675 and of VDE 0530 (Vorschriftenwerk Deutscher Elektrotechniker - German Electrotechnicians' Code requirements). The generators are also available designed and constructed in accordance with other code requirements for land and ship service.

2. Description of Functional Principle

All generators involved in this case are of the so-called internal pole type with stationary operating winding in the stator and rotating field winding in the rotor.

With a brushless design the excitation output of this rotating field winding is supplied by inductive transmission so that all contact systems which require maintenance and are liable to wear and tear can be omitted.

An exciter machine in the form of a three-phase external-pole synchronous machine is used for the inductive transmission, with the three-phase current unit of the machine being also arranged on the main generator shaft. The stationary field winding of the machine is supplied with current from the stator winding of the generator via a compounding system consisting of choke coil, current transformer and rectifier stack.

Prior to rectification of the summed current a current component which is load dependent and supplied by the current transformer is added vectorially to the alternating current, determined by the choke coil, for the no-load excitation.

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This compounding system has been so designed that the excitation output supplied by it at any load condition will be higher than that which is required for obtaining a constant generator voltage set point. The excessive excitation output available in the respective case is conducted by means of a transistor regulator via a step-down resistor which brings about the desired effect of a very narrow tolerance of the terminal voltage within the entire load range.

The current flowing in this way through the field coil of the exciter machine generates an alternating voltage in the rotating three-phase winding of this machine. This alternating voltage is rectified through co-rotating diodes and results in the direct current required for exciting the main generator. Hence this current can be supplied by way of direct line connection of the rotating field coil of the main generator.

The magnetic remanence in the iron parts of the exciter machine is utilised to initiate the self-excitation.

3. Design Features

The generator together with the exciter machine and all the components required for excitation and control form a compact unit. The generator is manufactured in JP 23 standard enclosure acc. to GDR standard TGL 15165 and is available in the types M 101 (B3), M 111 (B20), M 201 (B3/B5) and M 111/M 301 (B20/B5) of construction.

The spatial arrangement of the main assemblies of the generator can be seen from the following schedule:

Driving shaft end	A-side bearing	Blower	Stator and rotor of the generator	Stator and rotor of the exciter machine	B-side bearing	Controller and other components; diode support for rotating diodes
		Air outlet				Air inlet

The components located behind the B-side bearing are arranged below a cover of glass-fibre-reinforced polyester. This cover is provided with openings for cooling air admission at the front end and a mounting hole in the upper part which makes all essential components readily accessible when required.

3.1 Generator

Stator and rotor of the generator are constructed in compliance with the known principles of construction of modern synchronous machines. The rotor is available in the following constructional variants:

- as a salient-pole rotor up to including axle height h = 355 mm,
- as a smooth-core rotor with 4- and 6-pole generators from an axle height h = 400 mm on.

In the case of salient-pole rotors the poles are fixed by means of fillister-head screws with hexagonal recessed hole, made of material G 8.

An amortisseur winding is arranged in the pole shoe. The field winding consists of single- or multilayer pole coils which conform to heat resistance class F, these pole coils being mechanically supported against one another to resist the centrifugal forces occurring.

Supporting webs for carrying the stack of sheets are welded onto the centre portion of the shaft of the smooth-core rotor. This lamination is provided with air gaps analogous to the stator and is held together by means of stable clamp rings. The slots provided in the sheets serve to receive the field winding and the amortisseur winding arranged in the centre of each pole pitch. The individual amortisseur bars are short-circuited via the clamp rings.

The field winding consists of copper wires and complies to heat resistance class F. The coil ends are provided with a nonmagnetic tape to support them against centrifugal forces. The whole rotor is subjected to several vacuum impregnations.

Both types of rotor are dynamically balanced.

A sturdy cast or welded construction was chosen for the stator frame, depending on the size. For the special types M 111 (B 20) and M 111/M 301 (B 20/B 5) of construction the frames are so designed that it is possible, for instance, to screw on legs of different dimensions according to standard DIN 6281.

The location of the terminal box can be seen from the dimensional drawing and the marking of the terminals from the functional wiring diagramme.

The material used for the terminal board is in line with the degree of climatic protection of the generator for which it is

designed. Watertight cable inlets according to GDR standard TGL 6050 are provided for leading-in the cables.
In the terminal box and in the stator frame there are located a marked protective conductor connection each.
With the higher power applications the stator winding is designed as a two-layer preformed winding and in all other cases as a two-layer drop-in winding.
The slots are closed by means of wedges. A stable construction of the coil according to heat resistance class F is obtained through supporting rings (cylindrical metal rings) which retain the coil ends and by taping the coil ends and also by subjecting the complete stator to several vacuum impregnations with specialtype lacquer.

The A-side bearing bracket is designed with or without coupling flange, depending on the design variant. The coupling flanges are in compliance with SAE standard requirements and their classification is in line with generator sizes according to DIN 6281.

The A-side bearing bracket is either a cast or a welded construction, the B-side bearing bracket is principally a cast construction. Antifriction bearings are used as the bearings, namely

- on the A-side:
  cylindrical roller bearings of the medium-heavy series NU 3
- on the B-side:
  up to incl. h = 400 mm: grooved roller bearings of the medium-heavy series 63
  from h = 450 mm: cylindrical roller and grooved roller bearings used as a double bearing system.

The fixed bearing is always located on the B-side, the loose bearing on the A-side. From h = 315 mm on, all bearing systems are equipped with repacking devices with automatic control of the quantity of grease. Labyrinth seal rings built into the bearings make the bearings dustproof and in this respect being in compliance with JP 5 standard enclosure.

All bearings are amply dimensioned and are designed for a calculated service life of greater than 30,000 hours. It is imperative that the attached lubricating and maintenance instructions for antifriction bearings be strictly observed.

A radial blower located within the A-side bearing bracket provides an effective draft ventilation of the entire generator, with the cooling air being sucked in on the B side and blown out on the A side. Direction-of-rotation-dependent fans are partially used to reduce the noise nuisance due to the air blowing.

3.2 Exciter Machine

The stator of the exciter machine is mounted to the B-side bearing bracket and its pole system for direct-current generation protrudes into the generator. The pole coils consist of copper wires. The pertinent compounding system is explained in Item 5.2.

The rotor of the exciter machine is pressed on to the generator shaft in the form of a riveted stack of sheets and is fixed in place and secured against being turned by means of a knurled seat. The rotor carries the three-phase winding of copper coils, which are star-connected and coupled with the rotating diodes. These being in three-phase bridge connection are accomodated on a special diode carrier, in conjunction with the components for the protective circuitry. Since this carrier is seated external to the B-side bearing system on the generator shaft, it is readily accessible and does not pose any difficulties should an exchange of diodes become necessary. The lead wires from this diode carrier are passed directly to the field coil of the generator through the axial hole in the generator shaft.

4. Attachments

4.1 Thermal Winding Protection

A thermal stator winding protection for use of the generator under more severe operating conditions can be realized, on customer's request, by installing three series-connected thermally controlled sensistors. These sensistors, in connexion with an electronic module not included in the parts supplied by us, provide an initiating signal as soon as the stator winding starts to get overheated. The sensistor conductors are led to the terminal board and marked.

The thermal protection is imperative when the generators have to be equipped with cooling air filters. This provision does, however, not include a protection against thermal overloading of the rotor winding, e.g. when operating with power factors as low as smaller than cos phi = 0.8.

4.2 Heating Provided for Periods of Stoppage

For generators intended to be used in marine service or in tropical regions, a special insulation is provided which meets the requirements of the types T II or M II of climatic protection according to TGL 9200 (GDR standard). In these cases it is also possible, upon customer's request, to install a heating provided for periods of stoppage to prevent the generators from getting wetted with dew during prolonged periods of stoppage.

The heating consists of an insulated heating conductor which is arranged inside the generator on the A and B sides. The heating power amounts to 320 W when operated from a 42 volts dc or ac supply.

In this case the two marked terminals are also arranged on the terminal board.

Unintentional actuating of the "heating provided for periods of stoppage" during generator operation must be prevented by suitable measures (interlocking mechanism).

5. Description of the Exciter Equipment

5.1 Electric Function

The exciter equipment consists of the following essential assemblies as specified in the attached functional wiring diagramme:

- Choke coil for no-load excitation (6)
- Current transformer for load-dependent excitation (7)
- Compounding rectifier (8)
- Electronic voltage regulator (9) with step-down resistor r 25 and statics current transformer for parallel operation (10).

Self-excitation of the generator is based on the magnetic remanence. The remanent voltage generated at rated speed in the stator winding of the generator causes a small current to flow via the choke coil (6) connected to the phases U, V, W and via the rectifier stack (8) through the stator winding (4) of the exciter machine and effects initiation of the self-excitation procedure.
The choke coil (6) prevents the exciter current of the exciter machine from exceeding a specific value. This value is dependent upon the air gap between coil core and coil yoke and is so selected as to its size that the generator, with the electronic voltage regulator disconnected, gets excited until a voltage level is reached being about 10 % higher than the generator voltage (at rated frequency).
By means of the current transformer (7), through the primary winding of which the consumer current flows, an additional exciter current is generated required because of the armature reaction occurring when the generator is loaded. This current is added vectorially to the choke coil current and is also higher than that load-dependent proportion required for maintaining the rated voltage.
After rectification in the compounding rectifier (8), which is a six-pulse bridge connection, the entire exciting alternating current gets to the stator winding (4) of the exciter machine.

To protect the generator from voltage peaks, which may cause danger to the diodes, the rectifier stack (8) and the rotating rectifier (5) are provided with suitable transient voltage suppressors s 1 or s 2 (resistors, varistors or selenium transient voltage suppressors).
As soon as the rated voltage is exceeded, the step-down resistor r 25, which is connected in parallel with the compounding rectifier (8), is switched on by the electronic voltage regulator (9) by the aid of the power transistor p 3. In this way the effective current flowing through the stator winding (4) of the exciter machine is limited to a value required for maintaining the terminal voltage of the generator at a value preset by the set-point device r 11. A detailed functional description of the electronic voltage regulator is contained in item 6.

5.2 Design Features

All assemblies pertaining to the exciter equipment are mounted to the B-side bearing bracket of the generator and are covered with a cover permitting air to flow in and thus to cool the heat-dissipating components.

The three-phase no-load choke (6) consists of individual E-shaped dynamo sheets. On each salient pole one coil is arranged. Both ends of a coil are led to a terminal strip attached to the choke coil The yoke is mounted in such a way that the required air gap and hence the rated choke current can be adjusted.

The current transformer (7) is also three-phase and its steel sheet core structure is similar to that described for the choke coil. But in contrast to the no-load choke no air gap is provided between the core and the yoke. On the lower part of each salien pole there is arranged a primary winding of rectangular copper and above that the secondary winding on a separate coil base. In the case of higher output generators the compounding transformer may also consist of three single-phase current transformers.

The compounding rectifier (8) consists of six individual diodes with different flow directions, three of which having the respective polarity are in each case forced into a common cooling surface. The rectifier in combination with the transient voltage suppressor s 2 (overvoltage protector), the smoothing capacitor c_k and the step-down resistor r 25 form a compact assembly.

The electronic voltage regulator (9) is accommodated in an enclosed case in a dust- and dirtproof manner. The electronic components are arranged on a printed circuit board and are protected against impact and vibrations by an insulating sealing compound. Electric connection of the printed circuit board is via a plug board. In the enclosure there are also accommodated the transformer m 1 and the set-point device r 11, which can be adjusted by means of a screw driver from outside through an opening, however. The power transistor p 3 and the adjustable statics resistor r 26 are arranged external to the case to provide for better cooling and ready accessibility.

The statics current transformer is a component of the exciter equipment and is mounted to the bearing bracket as a separate component. Connection of the electronic voltage regulator and of the other assemblies is via terminal strips with the conductors marked in respective colours.

6. Function of the Electronic Voltage Regulator

The electronic voltage regulator as included in the attached functional circuit diagramme consists of the following functional groups:

- Current supply and actual value registration
- Set-point specification
- Variable-gain amplifier
- Sawtooth generator
- Comparator for pulse width modulation
- Exciter and output stage

The input transformer m 1, which on its primary end is connected with the generator phases U and V, has separate secondary windings for current supply (solder lugs 6 and 7) and for actual-value registration (solder lugs 4 and 5). Rectification of the supply voltage is effected by means of a two-pulse bridge circuit (n 1 to n 4). The capacitor c 1 is used for smoothing.

By means of the Z diodes n 15 and n 16 the supply current is divided into two zero-symmetrical components of equal magnitude and is stabilized. In this way the positive and the negative operating voltages for the operational amplifiers IS 1 and IS 2 are made available.

Another two-pulse bridge circuit (n 7 - n 10) effects the rectification of the actual-value voltage. The filter chain c 3, c 4, r 7 is intended to effect smoothing.

The statics current transformer (10) to be connected in the case of parallel operation has a direct effect on the actual-value registration. At the statics resistor r 26 there is a voltage drop, which is proportional to the load current. This will cause the generator voltage to show a more heavily decreasing tendency as the inductive load increases. Resistor r 26 is adjustable so that the statics of the generator can be adjusted as operating conditions may require.

The set-point voltage is obtained from the negative operating voltage (r 10, n 13). The variable resistor r 11 and the resistor r 12 form a voltage divider which makes it possible to adjust the no-load voltage of the generator in the planned range (see Item 7.3). Via a network (r 13 - r 15, c 9) the set point will get to the input of the variable-gain amplifier. The resistor r 13 becomes ineffective when a switchboard set-point device is connected.

The variable-gain amplifier consists of the operational amplifier IS 1. It becomes occupied with the actual value on the inverting inlet via a neutralizing resistor r 8 and on the non-inverting inlet with the stabilized set-point voltage derived from the operating voltage. Comparison between set value and actual value and the amplification of the differential voltage of the control deviation are effected in the variable-gain amplifier. The static gain is adjusted by means of r 9. The resistance-capacitance (RC) member c 15, r 24 forms a dynamic feedback device by means of which it is possible to obtain a desired transient response. Dimensioning of the feedback is dependent upon the type of generator and serves to obtain optimum adaptation of the control equipment (electronic voltage regulator) to the controlled system (generator).

The components r 17 and n 14 are designed to limit the output voltage of the variable-gain amplifier.

Phase locked mains synchronous operation of the regulator is ensured by means of a sawtooth generator which is triggered with the mains frequency. The pulses which effect a short-time actuation of transistor p 1 are generated by means of the two-pulse bridge circuit n 5 - n 8 and the components r 2, r 3 and n 11. This involves a very quick discharge of capacitor c 5 which had been charged via resistor r 5 during the blocked phase of p 1. The voltage across c 5 increases almost linearly during the charging procedure so that a sawtooth-shaped voltage curve is formed.

The operational amplifier IS 2 is connected as a comparator. The comparator compares the output signal of the variable-gain amplifier (difference between actual and set value) with the sawtooth voltage and changes to the reverse polarity whenever there is a voltage balance on the inlets. A pulse-width modulated square-wave voltage is generated at the outlet of the IS 2.

The driving transistor p 2 is located with its base on the outlet of the comparator, with the resistor r 18 being interconnected, and is triggered by the square-wave pulses. The nonstabilized supply voltage applied to the smoothing capacitor c 1 serves as the operating voltage of the driver stage. Transistor p 2 switches the output stage transistor p 3 which is located in the step-down circuit, together with resistor r 25, and which reduces the excitation to the level required for generator voltage stabilization.

7. Operational Behaviour

7.1 Self-excitation

Self-excitation is initiated by the remanent voltage of the generator. As soon as rated speed is reached, the voltage set by means of the set-point device is automatically adjusted.

Normally the remanent voltage of brushless generator is sufficiently high to ensure self-excitation even after stoppages. Should after especially long shut-down times the residual magnetism have become too small, self-excitation can be initiated by temporarily connecting a battery (6 V to 12 V) to the terminals K3, K4 in the terminal box of the generator (positive pole to K3, negative pole to K4). When the generator becomes excited, the voltage applied to the stator winding of the exciter machine exceeds the value of the battery voltage so that there will be a reverse current flux if the connection is not interrupted in time. Therefore, customers are recommended to provide an adequately loadable diode (note the flow direction) between the battery and the terminals K3 or K4 so as to prevent current direction reversal.

7.2 De-excitation

If the generator is to be de-excited with the prime mover runnung, short-circuit the terminals K3 and K4 via a contactor or a suitable switch. Then the terminal voltage of the generator will return to remanent voltage.

7.3 Voltage Control Range

By means of the set-point device r 11 the generator voltage may be adjusted within a range of ± 5 % of rated value. This resistor is factory-adjusted in such a way that the generator puts out the voltage indicated on the rating plate. The variable resistor r 11 is provided with a lock securing against automatic misadjustment; unscrew this lock before actuation and subsequently slightly tighten again.

It is possible, if required, to connect a switchboard set-point device (variable wire resistor 2.5 k ; 2.5 W) via the terminals K1 and K2 in the terminal box of the generator. Customers are recommended to use a shielded line for connection. Besides it is necessary that the bridge between the terminals R7 and R8 on the terminal strip of the voltage regulator be reversed to the terminals R6 and R7. The control range of the external set-point device is approx. ± 5 % of the rated voltage.

7.4 Voltage Stability and Settling Time

By the use of the electronic voltage regulator the set generator voltage is stabilised during static operation with a tolerance of ± 1.5 % between no-load and full-load, with power factors between $\cos \varphi = 0$ (inductive) and $\cos \varphi = 1$. This voltage stability is applicable also in the case of a speed drop of the prime mover of up to 5 % and is independent of the state of heating of the generator.

A throwing in of rated power at $\cos \varphi = 0.8$ results in a voltage dip of approx. 15 %. The settling time amounts to less than 300 m-sec.

7.5 Shape of Voltage

The generator voltage is practically sinusoidal. According to the general requirements the maximum deviation from the sine shape amounts to less than 5 %.

7.6 Degree of Radio Interference

The generators are in compliance with the "F1" degree of radio interference according to GDR standard TGL 20 855, or with "N" degree according to VDE 0875 if not otherwise agreed upon with the manufacturer.

7.7 Direction of Rotation

If the generator is to be operated in a direction of rotation opposite to that specified on the rating plate, inquiry with the manufacturer is an absolute requirement. If the generator is designed and suitable for use in both directions of rotation, merely the leads of the statics current transformer to the terminals R4, R5 of the voltage regulator need be exchanged (see Functional wiring diagramme).

7.8 Short-circuit Response

A stable permanent short-circuit current is ensured by means of the current transformer in the case of three-phase terminal short circuit. Generator and exciter equipment are so designed that they withstand the thermal and mechanical stresses in case of a short circuit. The permanent short-circuit current will reach a value of at least three times the generator current rating and is permissible over a period of up to 5 sec.

7.9 Single Operation

If the generator is to be used only in single operation, it is advisable to connect the terminals R4, R5 on the voltage regulator with a bridge (short circuit of the statics current transformer) in order to fully utilise the high voltage stability of the controlled design.

7.10 Parallel Operation

7.10.1 Synchronization

Connecting the generators in parallel can be done by method of fine synchronization, coarse synchronization or by quick synchronization. Thereby no special stresses will occur if fine synchronization is carried out properly by means of synchronoscope or lamp connexion and in the case of electronic balance by means of quick synchronization. The generator being~~x~~ at no-load condition will be switched on after frequency and phase compensation is precisely adjusted. Accurate voltage balance is, however, no absolute requirement, i. e., the voltage difference resulting from the different load conditions of the two systems to be connected has no disadvantageous effect on the synchronization procedure.

Coarse synchronization, preferably employed in the case of installations used in marine service, is effected through a central synchronizing air-core choke for all generators of an installation. As soon as a generator is connected (switched on), this synchronizing choke is temporarily interconnected between generator and bus bar so that the occurring balancing currents become limited to a permissible level. It is possible to connect (switch on) the excited generator without any additional voltage balancing with the two voltage systems being at whatever phase position relative to each other. A coarse frequency compensation is required in this case, with frequency differences of up to approx. 1.5 Hz permissible. The generator to be connected (switched on) should, however, always have the higher frequency so that it takes over actual load at once.

After the transient effect have died out, the choke is short-circuited by cutting in the generator power switch and is again available for connecting additional generators in parallel after the synchronizing switch has been cut out.

Make sure there is a time lag betwen cutting out the synchronising switch and short-circuiting the choke. If the current fluctuations prior to or after cutting in the power switch do not dye out, then the generator has not reached synchronism and the synchronising procedure must be repeated. After completion of the synchronising procedure the final load distribution is achieved as usual by respective adjustment of the Diesel fuel controller.

7.10.2 Statics Adjustment

For parallel operation of generators it is at any rate necessary to remove the bridge between the terminals R4 and R5 on the voltage regulator so that the statics current transformer starts to function. This causes the characteristic curve of voltage to assume a falling characteristic as a function of the current and of the power factor. This falling tendency of the characteristic can be varied by means of the statics resistor r 26 when the generator is stopped.

The factory-adjusted statics amounts to approx. 3 % at rated current and cos φ = 0.8. In this way a uniform distribution of the reactive load to the generators running in parallel is obtained without the use of a compensating lead.

The voltage stability obtainable in the case of parallel operation is dependent on the statics adjusted.

7.10.3 Parallel Run in Isolated Operation

There are no limitations to a parallel operation with generators, whether they have equal or different ratings, of the series 3 SBE/3 SBEV. Parallel operation with other types and with foreign makes presupposes that it is possible, with all generators, to adjust practically similar static voltage characteristics having a falling characteristic. Normally, this is possible with generators provided with electronic exciter equipment or other controlled systems (set-point device, variable statics). Besides the generators must be equipped with damping windings. To obtain a uniform distribution of actual load it is required that the speed governors of the prime movers be adapted to one another (same proportional-control zone).

When putting a unit into operation, a first and final adjustment of the generators is required, with the following items to be noted:

- Get no-load voltage of all generators to the same value by means of the set-point devices.
- Apply rated power, if possible, to all the generators in single operation, at rated power factor, and find out whether there is an approximately similar voltage dip with all generators. If there are substantial deviations, the statics resistors are required to be adjusted anew (stop the generator prior to readjustment). A statics of 3 to 4 % at rated power and rated power factor is sufficient to ensure stable parallel operation. This test must not be carried out with purely ohmic load applied since the statics remains ineffective in this case.
- Check whether all prime movers show a similar percentage speed drop between no-load and full-load when in single operation.

7.10.4 Parallel Operation with Mains

The stable parallel operation of an electric generator set on a "fixed" mains presupposes that overloading be avoided where the mains conditions vary.

On the side of the actual load application this will be ensured by an appropriate statics (speed drop) of the Diesel governor. If the mains frequency falls or rises, this will result - in compliance with the characteristic of the Diesel fuel - in a loading or deloading of the generator set.

In order to avoid reactive power overloads of a generator on the mains, the generator voltage is required to be lowered as the reactive power increases.

The generator can be adapted to all mains conditions and any load point can be adjusted through adjustment possibilities provided by means of the set-point device. The greater the statics, the smaller are the current variations with variations in the mains voltage.

7.11 Emergency Operation

If there is a defect on the voltage regulator and if no reserve regulator is available, it is possible to maintain an emergency operation. To this effect, disconnect the leads from the connection points R9, R10, R1 and R2 (R3) of the voltage regulator, fasten these points in a suitable way and provide the ends with a safe insulation. If the voltage regulator is to be removed from the generator for the purpose of repair, treat the remaining ingoing lines in the same way and also short-circuit the statics current transformer (10) on the secondary side (terminals k - l).

Connect a variable resistor, having a maximum value of approx. 100 Ω and a current-carrying capacity of at least 1 A, to the terminals K3, K4 in the terminal box of the generator. Caution! The resistor carries mains potential (to be protected against contacting).

By means of this resistor it is possible to adjust generator voltage rating at no-load condition. When loaded, keep voltage permanently under control and maintain it in the required range by readjusting (an as constant load as possible is of advantage). If one puts up with a greater voltage tolerance, a load-dependent readjusting can possibly be dispensed with.

8. Putting into Operation

8.1 Hints as Regards Problems of Connecting

Prior to putting the generator into operation, check once more whether the generator is connected in compliance with the functional wiring diagramme.

Note in particular the instructions contained in Items 7.1, 7.2, 7.3, 7.7, 7.9 and 7.10 of the present operating and maintenance instructions.

8.2 Voltage Changing with the Special Design Generator

If desired, the generators may be designed and constructed in such a way that operation is possible optionally on a 50 Hz and 400 volts supply and also on a 60 Hz and 450 volts supply. Changing over to the 60 Hz/450 volts is made by reversing the choke coil leads from X_1, Y_1, Z_1 to X_2, Y_2, Z_2 and by changing the ingoing line to the voltage regulator from R2 to R3 (see Functional wiring diagramme).

Prior to putting into operation, check whether choke coil and voltage regulator are connected to the terminals in accordance with the rated voltage desired and whether the speed of the prime mover is in line with the pertinent rated frequency.

9. Hints as Regards Trouble Shooting

9.1 Principal Remarks

When an error has occurred, stop the prime mover, as a general rule, for being able to subject the components of the exciter equipment and of the regulator to a visual inspection, with the equipment in a dead state.

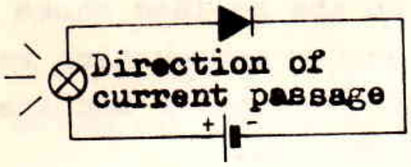
Should no obvious damages be detectable, such as scorched spots, burned components or parts of the winding, desoldered joints, loose clamp terminals, then check the exciter equipment while observing the instructions given below.

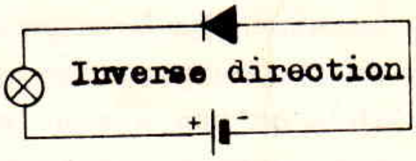
Any checks and any replacement of components must only be carried out with the equipment stopped.

9.2 Checking of Rectifier Diodes

Checking of diodes may be done by means of a wiring continuity checker. Prior to checking, disconnect the component concerned.

Connect the diode in series with a battery (approx. 3 volts to 6 volts) and an incandescent lamp and reverse polarity. The diode must permit current flow in one direction and block the flow in reverse direction.

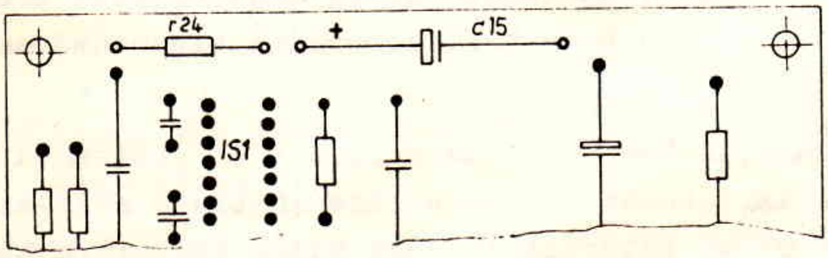




9.3 Exchange of Printed Circuit Boards or of Complete Voltage Regulators

A standard LP1 printed circuit board is used with all generators of the type series 3 SBE/3 SBEV. Only the components c15 and r24 depend upon the generator type. These are connected to the printed circuit board on the side of printed circuit board insertion by means of soldering lugs and will not be embedded into the sealing compound.

LP1 printed circuit boards may be exchanged irrespective of the generator size and rated voltage, on condition that an RC element (c15, r24) be inserted which is in compliance with original printed circuit board component insertion system. When making replacements, note the polarity of the electrolytic capacitor and disconnect the soldering iron from the mains (unplug the coupler plug).



LP1
side of printed circuit board component insertion

If the replacement of a complete voltage regulator is required, the above instructions should also be noted. In addition, make sure that input voltage of the reserve regulator is in compliance with rated generator voltage.

9.4 Error Check List

9.4.1 Generator does not get excited

- Check speed of the prime mover.
- Examine the terminal connexions on the no-load choke (6), on the current transformer (7), on the compounding rectifier (8), on the stator winding (4) of the exciter machine and the connections between these assemblies.
- Check whether there is a defect on the voltmeter in the switchboard.
- Check the diodes of the compounding rectifier (8) after it has been disconnected from the three-phase and direct current sides.

  If there is a defect, exchange either the complete rectifier or the diode support concerned. Three diodes each, having the same conducting direction, are forced into a common support (cooling plate). The second diode support is equipped with diodes of the reverse conducting direction (note this fact when making replacements and give diode type when ordering spare parts).
- Check the diodes of the rotating rectifier stack (5). To do this, unscrew (by loosening one screw) and remove the three cooling bodies equipped with one pair of diodes each, located outside of the B-side bearing on the generator shaft. When putting on again, make sure diode modules rest properly on the guide rings and note that screws be tightened accordingly.
- Remanent voltage is too small as a result of prolonged stoppage or other influences. In this case initiate self-excitation by means of an external voltage while observing the installations contained in item 7.1.

  If remanent voltage is to be measured, disconnect the connection between compounding rectifier (8) and stator winding (4) of the exciter machine for safety reasons.

  Do not touch live parts since the remanent voltage is normally within the range from approx. 15 to 50 volts.

9.4.2 Generator voltage is too low and cannot be increased by means of the set-point device

- Check the speed of the prime mover.
- Check whether the bridge between the terminals R7 and R8 of the voltage regulator is inserted and whether the switchboard set-point device is properly connected (note Item 7.3).
- Check the rectifier stacks (5) and (8) (see Item 9.4.1).
- Put voltage regulator out of operation by disconnecting the leads from R1, R2 (R3), R9, R10 (fasten and insulate the leads). Now a generator voltage of approx. 1.1 U_{rated} must be present at rated speed and no-load condition. If this is the case, there is a defect on the voltage regulator (note Item 9.3 when making replacements).
- If no reserve regulator is available, carry out emergency operation, if necessary (see Item 7.11).
- If voltage is still too low after putting the voltage regulator out of operation, check whether there is an air gap between core and yoke of the choke coil (6) and check the yoke fixing. Possibly enlarge the air gap so that a generator voltage of approx. 1.1 U_{rated} will be brought about without the voltage regulator.

9.4.3 Generator voltage is too high and cannot be reduced by means of the set-point device

- Check the connections R1, R2 (R3), R9, R10 on the voltage regulator.
- Put the voltage regulator out of operation (see Item 9.4.2) and check whether a generator voltage of approx. 1.1 U_{rated} will be brought about. If this is the case, replace voltage regulator or LP1 printed circuit board (note Item 9.3).
- If no reserve parts are available, possibly carry out emergency operation (see Item 7.11).

- If voltage is still to high after putting the voltage regulator out of operation, check the choke coil (6) for shorted turns and check yoke fixing. Possibly reduce air gap so that a generator voltage of approx. 1.1 U_{rated} will be brought about.

9.4.4 Generator voltage is substantially reduced when load is applied

- Check the speed of the prime mover.
- Check the rectifier stacks (5) and (8) (see Item 9.4.1).
- Check the current transformer (7) and the connexions between choke coil (6), current transformer (7) and rectifier (8).
- Check - or clean if necessary - the contact clamp on the static resistance r 26.
- Reduce the statics adjustment (see Item 7.10).

The bridge between the terminals R4 and R5 can only be switched in with the generator in pure single operation (see Item 7.9).

9.4.5 Current overload in the case of parallel operation

- Check distribution of actual load (see Item 7.10.3).
- Check whether statics is effective (see Item 7.10.2).
- Check whether direction of rotation is in compliance with rating plate data (note Item 7.7).
- Should one generator take up too much reactive power as the load increases, increase statics of this generator or reduce statics of the other generators (a value of 3 % must not be exceeded).
- If the measures specified above do not turn out to be a success, the whole installation must be adjusted anew (see Items 7.10.3 and 7.10.4).
  Before doing this, check all generators for proper functioning while used in single operation.

9.4.6 Generator voltage oscillates

- Check speed governor of the prime mover.
- Put voltage regulator out of operation (see Item 9.4.2). Check whether generator voltage is stable. If this is the case, check or replace capacitor c15 and resistor r24 on the LP1 printed circuit board or use reserve regulator.
- If necessary, carry out emergency operation (see Item 7.11).

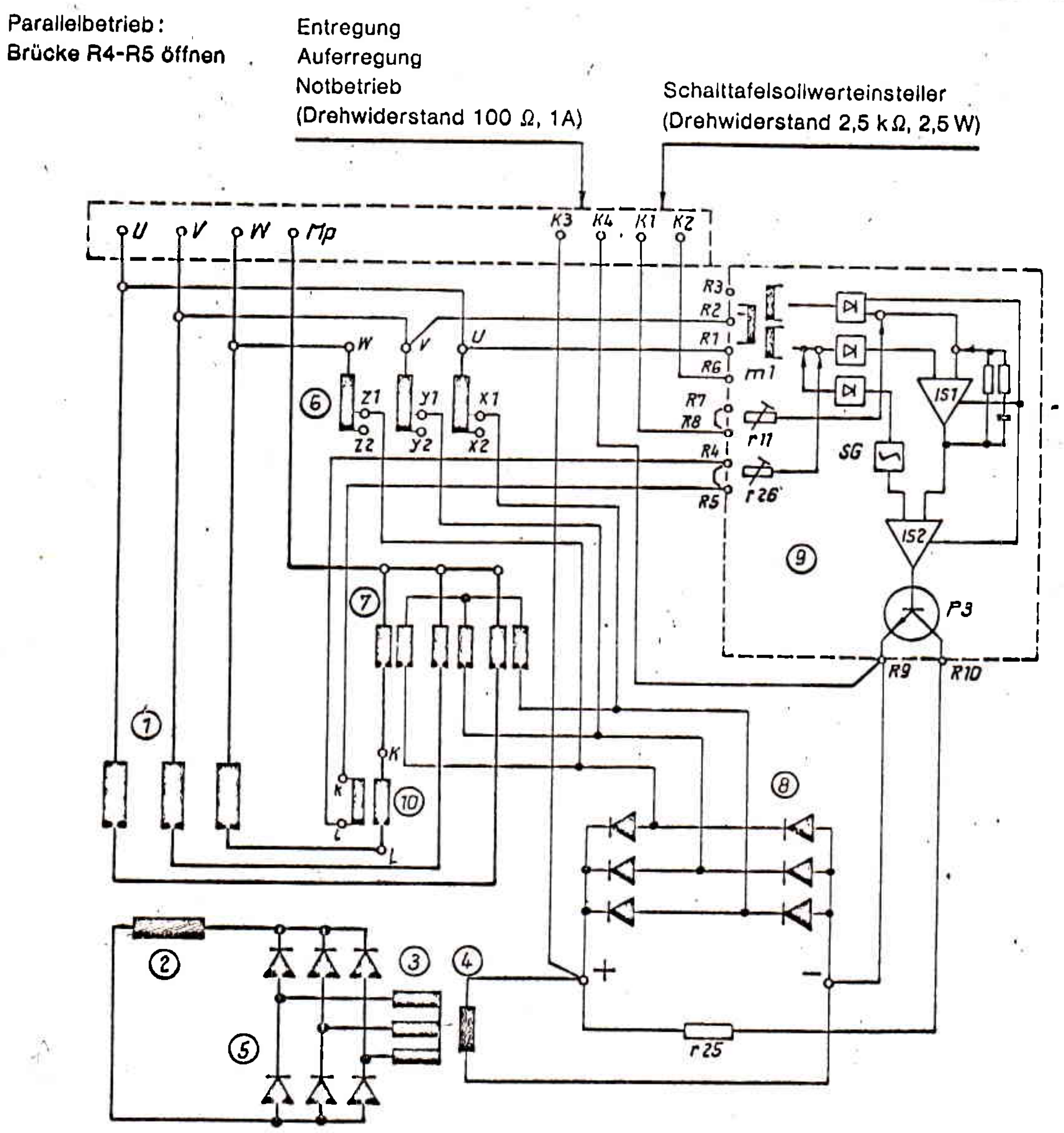
10. Dismantling of the End Shield on the B Side

As the entire exciter set is mounted to the B side end shield, the following instructions should be observed when dismantling of the end shield is required (eg. for replacement of the bearing):

- Disconnect wires from terminals K1 to K4 on the terminal board and pull them to the inside.
- Disconnect wires UVW (blue, brown, black), which feed the exciter set, from the terminal strip.
- Disconnect wires of the primary winding provided at the current transformer.
- Disconnect the 5 connecting wires from the diode holder.
- Remove thrust washer from the diode holder. Now the entire diode holder can be taken off.
- Unscrew the 4 bolts provided at the frame of the exciter machine so that the exciter frame can remain in the machine after the end shield has been removed.
- Unscrew the bolts provided at the board ring. After this it is possible to dismantle the bearing components and to remove the end shield together with the entire exciter set.
- When re-assembling proceed in the reverse order. Make sure that all wires are properly reconnected in accordance with the wiring diagram given.

[illegible]
HAMBURG
D-2000 HAMBURG 55 · POSTFACH 770
AGGREGATEBAU

Offer No. 8888/80



Parallelbetrieb:
Brücke R4-R5 öffnen

Entregung
Auferregung
Notbetrieb
(Drehwiderstand 100 Ω, 1A)

Schalttafelsollwerteinsteller
(Drehwiderstand 2,5 kΩ, 2,5 W)

① Statorwicklung des Generators
② Rotor- (Erreger-) Wicklung des Generators
③ Rotor- (Drehstrom-) Wicklung d. Erregermaschine
④ Stator- (Erreger-) Wicklung der Erregermaschine
⑤ Gleichrichter, rotierend
⑥ Drossel für Leerlauferregung
⑦ Stromtransformator f. lastabhängige Erregung
⑧ Kompoundierungs-Gleichrichter
⑨ Regler
⑩ Statik-Stromwandler für Parallelbetrieb

m¹	Versorgungstransformator
r¹¹	Sollwerteinsteller
r²⁵	Absetzwiderstand
r²⁶	Statikeinstellwiderstand
SG	Sägezahngenerator
JS 1, JS 2	Integrierte Schaltkreise
p³	Absetztransistor

	Prinzipschaltbild für bürstenlose Generatoren (Regler 3)	**097-002 : 112**

Conexion para éstatismo Reactiva

Drahtdrehwiderstand 2, , 2,5 W

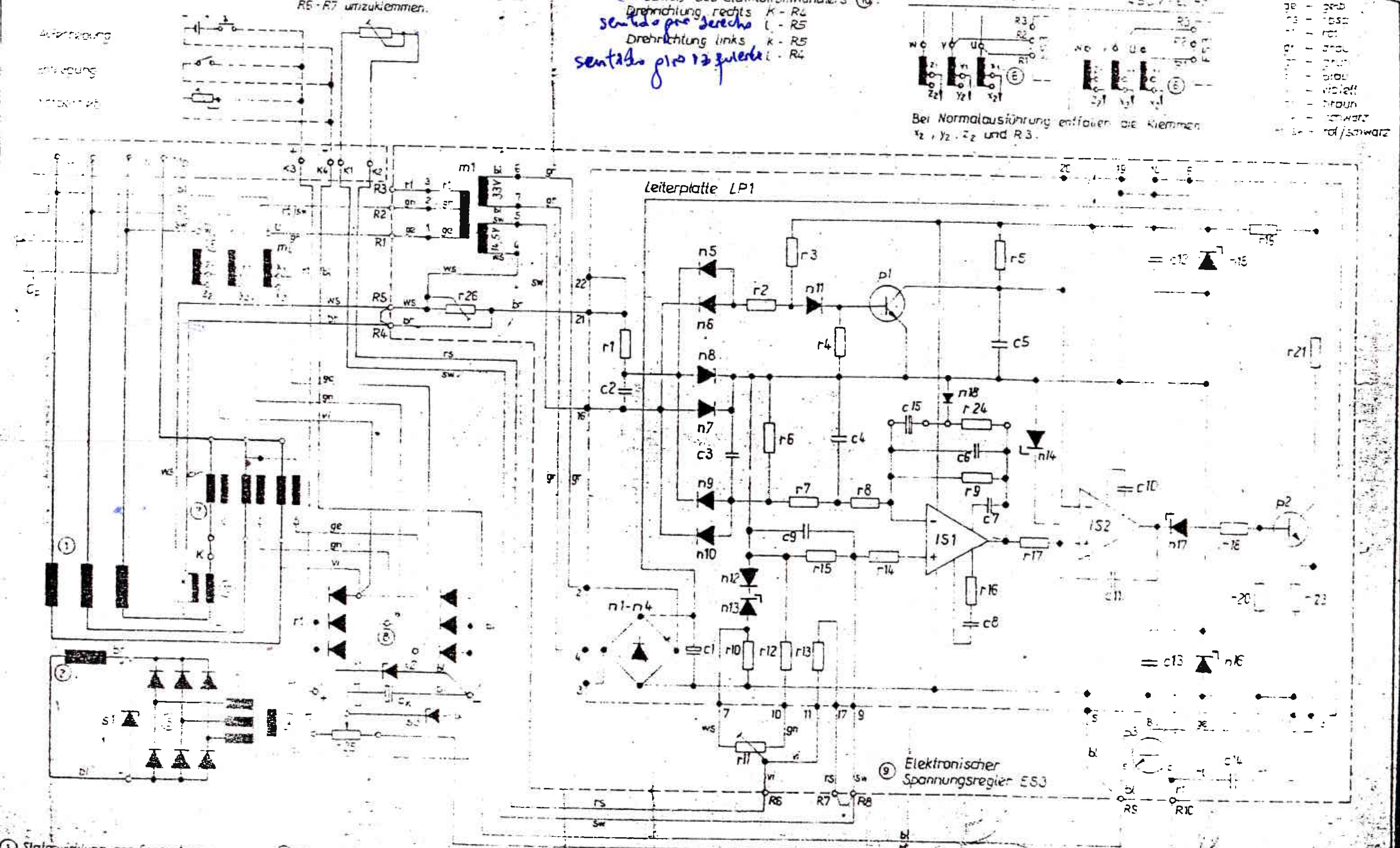
Bei Anschluß eines Sch al - Sollwerteinstellers ist die Brücke R7-R8 auf R5-R7 umzuklemmen.

Bei Parallelbetrieb Brücke R6-R8 entfernen!

Anschluß des Statikstromwandlers ⑩:

Drehrichtung rechts K - R4
sentido pro derecho l - R5

Drehrichtung links k - R5
sentido giro izquierdo l - R4


400 V/50 Hz
450 V/60 Hz
W V U
R3 R2 R1
z1 y1 x1
z2 y2 x2
E
m1
33 V
14,5 V
K3 K4 K1 K2
R3 R2 R1 R5 R4
r26
Leiterplatte LP1
n5 n6 n8 n7 n9 n10
r1 r2 r3 r4 r5 r6 r7 r8 r9 r10 r12 r13 r14 r15 r16 r17 r18 r19 r21 r24
c1 c2 c3 c4 c5 c6 c7 c8 c9 c10 c11 c12 c13 c14 c15
n11 n12 n13 n14 n16 n17 n18
p1 p2
IS1 IS2
n1-n4
r11
R6 R7 R8 R9 R10
Elektronischer Spannungsregler ES3
ws br rs sw gn ge vi bl gr rt
s1 s2 s3
K k
Cx
CF

Bei Normalausführung entfallen die Klemmen x_2, y_2, z_2 und R3.

ge	gelb
rs	rosa
rt	rot
gr	grau
gn	grün
bl	blau
vi	violett
br	braun
sw	schwarz
rt/sw	rot/schwarz

① Statorwicklung des Generators
② Rotor-(Erreger-)wicklung des Generators
③ Rotor-(Drehstrom-)wicklung d. Erregermasch.
④ Stator-(Erreger-)wicklung d. Erregermasch.
⑤ Gleichrichter, rotierend

⑥ Drossel f. Leerlauferregung
⑦ Stromtransformator f. lastabhängige Erregung
⑧ Kompoundierungs - Gleichrichter
⑨ Regler
⑩ Statik - Stromwandler f. Parallelbetrieb

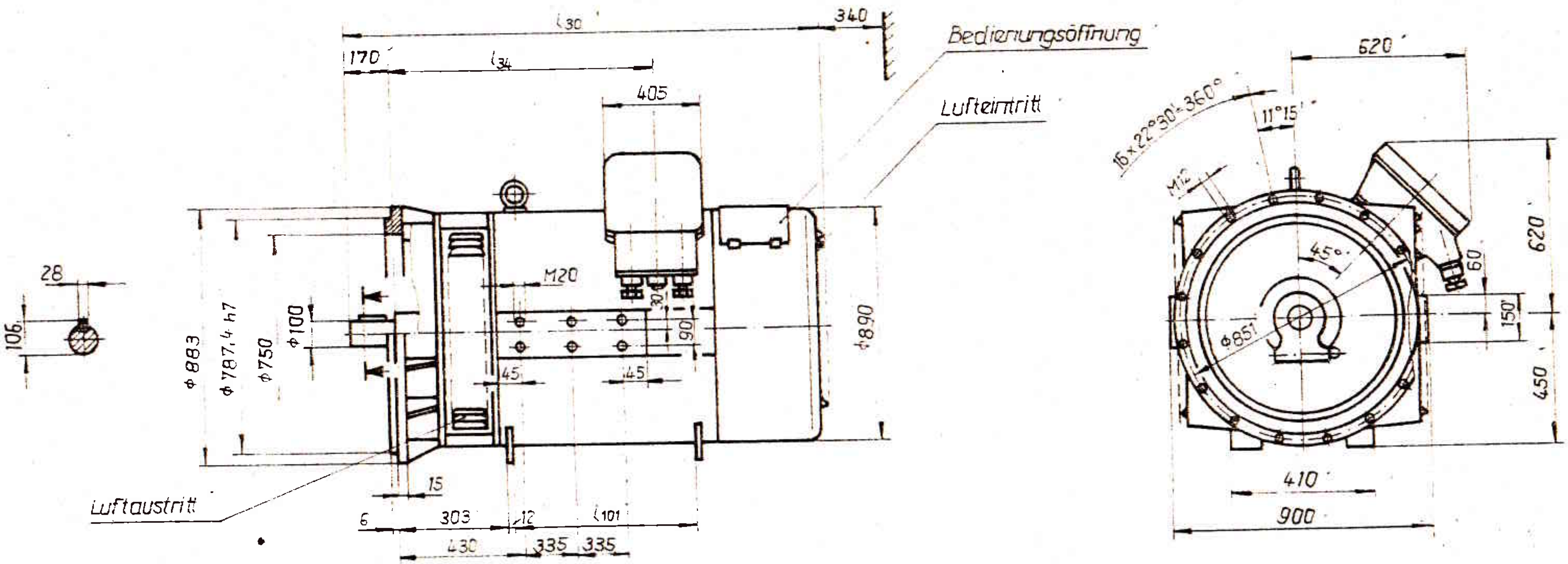
r 11 Sollwerteinstellwiderstand
r 25 Absetzwiderstand
r 26 Statikeinstellwiderstand
s1, s2, s3 Überspannungsbegrenzer
c_x Stützungskondensator

c_F Funkentstörkondensatoren

VEB
Elektromotorenwerk
Dessau

Funktionsschaltplan für bürstenlose Generatoren

097-002:1083



Baugröße	Kenn-größe	Masse kg	l_{30}	l_{34}	l_{101}
3 SBEV 455-4	G	2820	1936	1156	1046
3 SBEV 456-4		3200	2056	1276	1166

Passungen: Wellenstumpf : m 6
Gegenstück : H 7

VEB
Elektromotorenwerk
Dessau

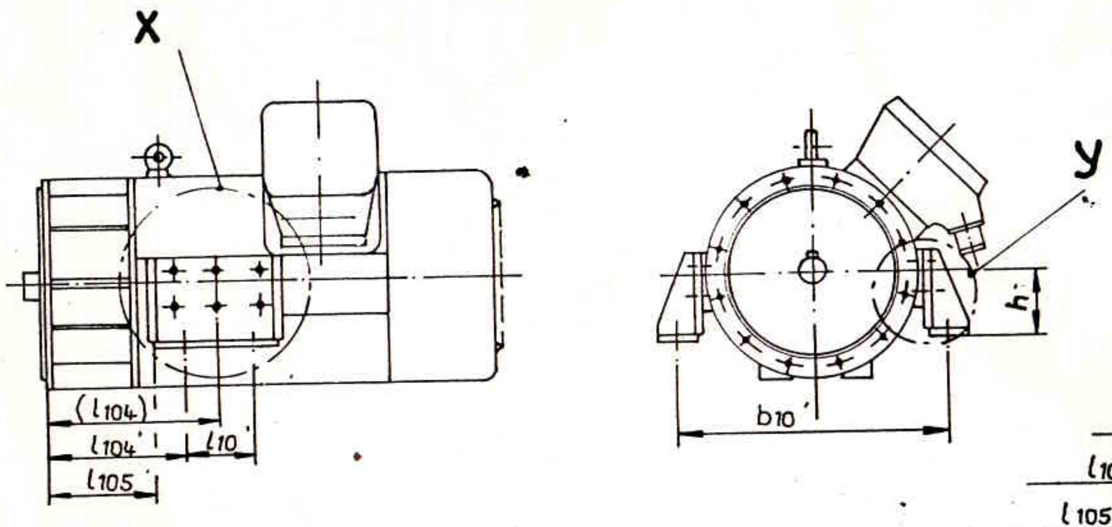
Gez.: 11.12.78 Jde.
Gepr.:
Ersatz für:
Ersetzt durch

Drehstrom - Synchrongenerator

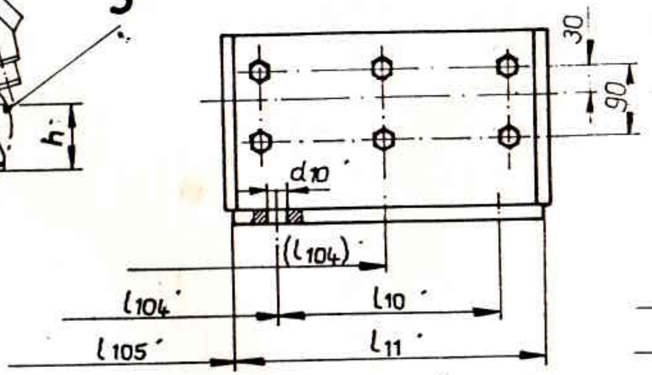
bürstenlos
Flansch: SAE 00
Bauform: M 111 / 301 (B5/B20) Schutzgrad: IP 23
Kühlsystem: IC 01

Zeichnungs-Nr.:
M 3 - 600

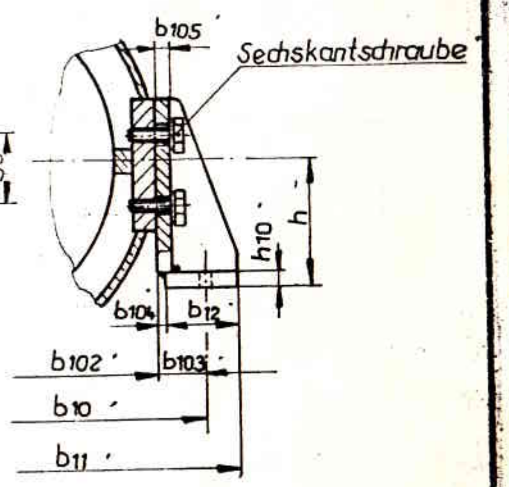
Ing. Aresqueta C.H. Terra.



Einzelheit X



Einzelheit Y



Baugröße		b10	b11	b12	b102	b103	b104	b105	h	h10	d10	l10	l11	l104	l105	Befestigungs-löcher je Fuß	Sechskantschr. TGL 0-933
3SBE	285-4 286-4	700	790	90	600	50	5	12	125	12	24	–	238	425	306	1	M12×35
3SBE	315-4 316-4	820	906		710	55	8	16		20	28	280	400	385	325	2	M16×50
3SBE	355-4 356-4																
3SBEV	405-4 406-4 407-4	970	1066	100	850	60			185		35			460	400		
3SBEV	455-4 456-4	1020	1116		900							630	740				M20×50

VEB
Elektromotorenwerk
Dessau

Gez. 20.9.78 a.d.M.
Gepr. h.h.
Ersatz für:
Ersetzt durch

Fußabmessungen für Synchrongeneratoren
in Bauform M 111 / 301 (B5 / B20)

Zchngs.-Nr.
093-450:554 (4)

VEM

THREE - PHASE ALTERNATOR
bruhsless
Spare Parts List

Type: 3 SBEV 456 - 4, 95o kVA

1.	endshield a.s.
2.1.	external plummer block cover
2.2.	interior plummer block cover
2.3.	external labyrinth socket
2.4.	interior labyrinth socket
2.5.	cylindrical roller bearing
3.	endshield b.s..
4.1.	see point 2.1
4.2.	see point 2.2
4.3.	see point 2.3
4.4.	see point 2.4
4.5.	prooved ball bearing
5.	fan
6.	terminal box
6.1.	terminal box cover
7.	terminal board
8.	regulator
8.1.	printed circuit board
9.	choke
lo.	current transformer
11.	rotating rectifier set
11.1.	diode carrier
12.	rectifier set

GEBR. PAPROTTKA GMBH
HAMBURG
AGGREGATEBAU